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EFFECT OF INOCULATION WITH PHOSPHATE-BACTERIA, SAWDUST COMPOST AND NITROGEN SOURCES ON OKRA YIELD AND SOME PROPERTIES OF A CALCAREOUS SOIL

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ABSTRACT

Two pot experiments were carried out during the seasons of 1999 and 2000 at Agricultural Research Center in Giza using a calcareous soil media to investigate the effect of phosphate dissolving bacteria (PDB) inoculation, sawdust compost and different nitrogen sources on growth and yield of okra plants. Moreover, the changes in some biological and chemical properties of the used soil after 175 days of planting were also recorded. *Bacillus megatherium* var *phosphaticum* was used as inoculum at the time of planting. While, two rates from sawdust compost were used, i.e. 2.5% and 5% in addition to the control treatment. The nitrogen fertilizer was added at four sources namely, (B) nitric acid solution (0.1N), (C) nitric acid- calcium nitrate (1:1) mixture, (D) calcium nitrate solution and (E) urea solution on nitrogen basis compared with no mineral nitrogen application (A). The obtained results indicate that, inoculation of okra plants with PDB and addition of sawdust compost significantly increased plant growth, fruits yield and nutrients uptake. The highest increments of this parameter were achieved under used higher compost rate (5%) than 2.5%. The obtained results show also that, nitrogen fertilization was very important to okra plants in such soil regardless the form of added nitrogen. On the other hand, the completely and partially acidic nitrogen form induced a positive effect on the availability of nutrients such as P and K which is reflected on uptake by plant fruits. Viable microbial counts, phosphate dissolving bacteria and dehydrogenase activity in the soil as well as the availability of mineral N, P and K were enhanced by organic manuring and inoculation with PDB. Moreover, the addition of organic manure increased the organic matter percentage in the soil and lead to a slight decrease in its pH value. Therefore, adding sawdust compost to a calcareous soil in presence of acidic nitrogen fertilizer form as well as PDB inoculation could be recommended to obtain the best results for okra fruits yield and favourable nutrients uptake.

Keywords: Phosphate-bacteria, Sawdust compost, Okra plant, Calcareous soil.

INTRODUCTION

Organic manures serve two purposes in the soil; they supply both major and minor nutrients for plants and microorganisms. They also improve the physical and chemical conditions in the soil, (Luo and Sun, 1994; Estefanous et al., 1997 and Mohamed and Gamie, 1999). Many trails have been conducted to obtain good quality compost from sawdust. Montagu and Goh(1990) mixed it with chicken manure and other organic matter. and Kropisz (1992) composted it for four months, while Marsh and Rixon (1991) added it to the soil as a raw material.

The effect of biofertilization with phosphobacteria (phosphate dissolving bacteria-PDB) was studied by many investigators, Abd El-Lateef et al. (1998) found a significant response to this biofertilization on yield component characters, seed quality, protein and oil percentages of soybean, sesame and sunflower. While, Koreish *et al.* (1998) found that soil nutrients especially phosphorus and micronutrients were significantly improved by PDB inoculation. They also found that inoculation by PDB enhanced nutrients uptake by maize plants and all their measured yield components compared to uninoculated treatments. On the other hand, Saad and Hammad (1998) found that the greatest plant height, fresh and dry weight per plant, plant P%, grain and straw yields, and highest density of phosphate dissolving bacteria in the wheat rhizosphere, was found with inoculation of PDB + mycorrhizas and application of Ca-superphosphate.

The effect of NO_3^-- N and NH_4^+-N on acidification of the bulk soil was studied by Thomson *et al.* (1993), where they found that, the nutrients availability increased due to acidification of the rhizospher. Also, Wen *et al.* (2000) used several N sources including urea in addition to NO_3^-- N and NH_4^+-N in the comparison and mentioned that, assimilation of urea N reduced N uptake by plants at seedlings stage and increased it at the subsequent stages.

Okra is one of the most important crops in Egypt for local market. The productivity of okra plants can be improved through application of organic matter and biofertilization, (Selvi and Perumal1997 and Ritzinger *et al.*,1998). The aim of this study was to investigate the efficiency of PDB inoculation, sawdust compost amendment and different nitrogen sources on growth and yield of okra plants. Moreover, the changes in some biological and chemical properties of the used calcareous soil after 175 days of planting were also recorded.

MATERIALS AND METHODS

Two pot experiments were carried out at ARC at Giza, Egypt during the two successive seasons of 1999 and 2000. The soil used was calcareous soil collected from the upper 30 cm layer of Nobaria Research Station farm. The physical and chemical properties of the used soil were determined according to Page et al. (1982) and recorded in Table (1). The compost used was a composted mixture of fine sawdust, cattle dung and ammonium sulphate (20.5%N) at the rate of 100:100:5.36 kg, respectively. This compost has a pH of 7.9, total solids 48.9%, organic matter 58.52%, total nitrogen 1.28% and C/N ratio 26.5:1. Inoculum used was prepared in Soil, Water and Environ. Res. Inst., ARC, Giza using broth culture of *Bacillus megatherium* var *phosphaticum* contained *ca* 10^8 cells ml^{-1} carried on vermiculate based (1:3 v/w) as local carrier material.

The soil was passed through a 2 mm sive and distributed in ninety earthware pots at the rate of 7 kg soil per pot. The pots grouped into 3 sets i.e. without compost addition and with compost addition at rates of 2.5% and 5% of soil weight. Seeds of okra variety Esmaily (provided from Horti. Res. Inst. ARC, Giza, Egypt) were sown at the rate of 3 seeds per pot on the first week of March and thinned to one healthy seedling per pot after 2 weeks.

The inoculated treatments seeds of okra were inoculated with the inoculum at a rate of 600 g inoculum per 40 kg seeds using 16% gum Arabic solution as a sticking agent at a rate of 300 ml per 40 kg seeds. The pots were irrigated with tap water when they needed to reach their field capacity.

Table (1): Physical and chemical properties of the used soils in both seasons.

Properties	1999	2000	Properties	1999	2000
C.sand	11.10	10.67	Available P(ppm)	10.80	8.90
F.sand	24.30	29.34	Available K(ppm	275.0	250.0
Silt	26.75	27.31	Cations,(meq/100g soil):		
Clay	37.85	32.68	Ca^{2+}	1.82	1.86
Texture class	clay loam		Mg^{2+}	0.79	0.75
$CaCO_3$%	26.00	28.10	Na^+	3.10	3.00
Organic matter%	0.87	0.75	K^+	0.39	0.35
pH(1:2.5) suspention	7.90	8.00	Anions,(meq/100g soil):		
CEC(meq / 100 g soil)	16.80	15.40	CO_3^{-2}	--	--
EC*(dS^{-1}/m)	0.91	1.20	HCO_3	0.90	0.95
Total N %	0.09	0.06	Cl^-	2.91	2.83
Available N(ppm)	54.60	40.30	SO_4^{-2}	2.29	2.18

*Ec in 1:5 soil extract.

At the beginning of the 3rd week, 5 nitrogen treatments were applied *i.e,*(A) control without any nitrogen fertilization, (B) solution of diluted nitric acid (0.1N), (C) solution of diluted nitric acid-calcium nitrate (1:1) mixture, (D) solution of calcium nitrate and (E) urea solution. All of these sources were added at one rate (40 kg N per feddan), (1 feddan = 0.42 ha), 35 mg N in each dose every 2 weeks (280 mg N per pot containing 7 kg soil as a total of 8 doses).

Factorial design with three replicates was adopted. Dipotassium phosphate dihydrate in a solution was added to the pots in two equal doses, 2 and 5 weeks after sowing each contained 0.449 gm of salt in 500 ml of water per pot corresponding to 25 and 50 kg P_2O_5 and K_2O per feddan. Okra fruits were collected starting from the 20th week and till the 25th week after planting where, after that the plant were cut and rhizosphere soil samples from each treatment were taken for chemical and biological determination.

- Total yield was determined as the weight of the fruits harvested during the whole period of growth.
- Dry matter content determined in both fruits during harvesting period and in plant shoots at the end of the experiments.
- Fruits N and P contents were determined in fine powder of the dry fruits according to the methods of Chapman and Pratt (1961).
- Soil reaction (pH), available N and P were assayed according to methods recorded by Jackson (1973). Organic matter was estimated according to Black et al. (1965).
- The viable microbial counts and phosphate dissolving bacteria were estimated by the standard plate count method using soil extract agar medium (Allen, 1953) and Bunt and Rovira medium modified by (Abdel-Hafez, 1966),

respectively. Dehydrogenase activity in the soil was assayed by the method described by Casida et al. (1964).

- Statistical analysis was carried out according to Snedecor and Cochran (1980) using L.S.D. to compare the significance of results.

RESULTS AND DISCUSSION

Okra yield and growth:

Data of fruits fresh and dry weights as well as shoots dry weights of okra plants are shown in Tables (2 and 3), respectively. Generally, growth of okra plants responded favourably to phosphate dissolving bacteria (PDB) inoculation and /or compost amendments in both seasons. Plants inoculated with PDB gave remarkable increase in these parameter compared to non-inoculated ones. However, these increases were more pronounced with non-amended soil than with those treated with organic manure. In the other words, addition of higher amounts (5%) of sawdust compost to soil reduced the differences between the inoculated and non-inoculated plants due to improved growth of the non-inoculated plants resulted from supplementation with the organic amendments. In this concern, Abd El-Lateef *et al.* (1998) found a significant response to biofertilization with PDB on yield component characters of soybean, sesame and sunflower. The stimulating influence of organic amendments on okra vigour might be attributed to improving the microbial activities in soil and this probably improves the availability of the nutrients. Similar results were obtained by Selvi and Perumal(1997) and Ritzinger et al.(1998) who found that the productivity of okra plants can be improved through application of organic matter and biofertilization.

Table (2): Effect of sawdust compost, phosphate dissolving bacteria inoculation and nitrogen treatments on okra yield (g/pot fresh weight basis).

Inoc.	Compost rate %	Nitrogen treatments						L.S.D at 0.05 Level	
		A	B	C	D	E	Mean		
1st season									
Non-inoc.	0	33.90	75.47	53.28	54.92	47.69	53.05	Inco	8.07
	2.5	48.29	75.94	71.19	66.22	62.60	64.85	Comp.	8.87
	5	72.55	96.96	80.34	85.43	76.50	82.36	N	9.26
	Mean	51.58	82.79	68.27	68.86	62.26	66.75	Inoc x comp.	N.S
Inoc.	0	40.96	82.49	76.84	75.71	68.02	68.80	Inoc. x N	N.S
	2.5	48.76	90.85	99.89	75.77	76.05	78.26	Comp. x N	N.S
	5	74.94	97.92	86.86	74.58	79.98	82.86	Inoc. x comp. x N	N.S
	Mean	54.89	90.42	87.86	75.35	74.68	76.64		
Mean		53.24	86.61	78.07	72.11	68.47	71.70		
2nd season									
Non-inoc.	0	34.82	71.81	58.83	57.47	44.52	53.49	Inco	4.83
	2.5	56.18	78.49	63.79	70.48	57.80	65.35	Comp.	7.39
	5	76.59	100.12	74.05	98.95	67.18	83.38	N	7.51
	Mean	55.86	83.47	65.56	75.63	56.50	67.41	Inoc x comp.	N.S
Inoc.	0	41.68	88.96	92.71	72.81	68.10	72.85	Inoc. x N	10.81
	2.5	57.49	95.32	90.15	72.83	73.88	77.93	Comp. x N	N.S
	5	80.71	109.18	93.79	95.12	86.17	92.99	Inoc. x comp. x N	N.S
	Mean	59.96	97.82	92.22	80.25	76.05	81.26		
Mean		57.91	90.65	78.89	77.94	66.28	74.34		

Inoc. = Inoculation

Table (3): Effect of sawdust compost, phosphate dissolving bacteria inoculation and nitrogen treatments on dry weight of okra yield and shoots (g/pot).

Inoc.	Compost rate %	Nitrogen treatments A	B	C	D	E	Mean	L.S.D at 0.05 Level	
				1st season, yield					
Non-inoc.	0	5.00	11.20	7.86	8.11	7.10	7.85	Inco	: 1.19
	2.5	7.18	11.20	10.50	9.77	9.23	9.58	Comp.	: 1.30
	5	10.72	14.30	11.85	12.60	11.28	12.16	N	: 1.36
	Mean	7.65	12.23	10.07	10.16	9.20	9.86	Inoc x comp.	: N.S
Inoc.	0	6.08	12.33	11.33	11.17	10.03	10.19	Inoc. x N	: N.S
	2.5	7.19	13.40	14.73	11.17	11.22	11.54	Comp. x N	: N.S
	5	11.05	14.44	12.81	11.00	11.80	12.22	Inoc. x comp. x N	: N.S
	Mean	8.11	13.39	12.96	11.11	11.02	11.32		
Mean		7.88	12.81	11.52	10.64	10.11	10.59		
				2nd season, yield					
Non-inoc.	0	5.14	10.59	8.68	8.48	6.57	7.89	Inco	: 0.71
	2.5	8.29	11.58	9.41	10.40	8.53	9.64	Comp.	: 1.09
	5	11.30	14.77	10.92	14.59	9.91	12.30	N	: 1.11
	Mean	8.24	12.31	9.67	11.02	8.34	9.94	Inoc x comp.	: N.S
Inoc.	0	6.15	13.12	13.67	10.74	10.05	10.75	Inoc. x N	: 1.59
	2.5	8.48	14.06	13.30	10.74	10.90	11.50	Comp. x N	: N.S
	5	11.90	16.10	13.83	14.03	12.68	13.71	Inoc. x comp. x N	: N.S
	Mean	8.84	14.43	13.60	11.84	11.21	11.99		
Mean		8.54	13.37	11.64	11.43	9.78	10.97		
				1st season, shoots					
Non-inoc.	0	28.30	32.33	35.23	37.26	34 .20	33.47	Inco	: N.S
	2.5	31.87	43.13	32.90	41.20	36.37	37.10	Comp.	: N.S
	5	35.50	44.37	34.83	38.57	36. 13	37.88	N	: 2.91
	Mean	31.89	39.94	34.32	39.01	35.57	36.15	Inoc x comp.	: N.S
Inoc.	0	34.40	35.37	36.23	37.63	37.13	36.15	Inoc. x N	: N.S
	2.5	37.33	38.87	37.30	40.47	37.63	38.32	Comp. x N	: N.S
	5	37.80	40.73	38.10	41.47	43.90	40.40	Inoc. x comp. x N	: N.S
	Mean	36.51	38.32	37.21	39.86	39.55	38.29		
Mean		34.20	39.13	35.78	39.43	37.56	37.22		
				2nd season, shoots					
Non-inoc.	0	31.03	35.87	33.67	35.90	32.53	33.80	Inco	: 1.41
	2.5	34.70	41.43	35.30	38.07	34.80	36.86	Comp.	: 1.81
	5	36.33	47.63	37.93	38.23	39.53	39 .9 3	N	: 3.04
	Mean	34.02	41.64	35.63	37.40	35.62	36.86	Inoc x comp.	: N.S
Inoc.	0	33.20	37.87	35.03	36.80	39.67	3 6.51	Inoc. x N	: N.S
	2.5	40.70	45.13	39.47	44.97	41.47	42.35	Comp. x N	: N.S
	5	43.80	46.43	40.23	48.50	46.57	45.11	Inoc. x comp. x N	: N.S
	Mean	39.23	43.14	38.24	43.42	42.57	41.32		
Mean		36.63	42.39	36.94	40.41	39.10	39.09		

Inoc. = Inoculation

Fertilization with any form of nitrogen caused significant increases of fruits fresh and dry weights as well as shoots dry weights of okra plants than the control treatments in both seasons. The three forms of nitric acid solution (form B), nitric acid-calcium nitrate (form C) and calcium nitrate (form D) showed the highest values of dry matter content and total fresh weights of okra fruits in each seasons. These values were generally higher than urea treatment (form E) which was significantly higher than control treatments (form A). While in the case of okra shoots dry matter content, forms B, D and E showed the highest values in each season and were generally higher than form C. These results may be due to the assimilation of any ready nitrogen form added to the soil in presence of organic compost at the early weeks after application. In this concern, Thomson et al. (1993) found higher dry weight of tomato shoots and roots by more acidification of bulk soil and rhizospher and was confirmed with the increase of dry matter in plants received nitric or nitrate-N forms than urea. Also, many trials indicated the superiority of NO_3-N than urea and each of them to control as those of Fenn and Feagley(1999) who attributed this effect due to more ready N to be absorbed by plants.

The double and triple interaction of the three individual factors (compost, inoculation and nitrogen treatments) showed non significant effect on fruits fresh and dry weight as well as shoots dry weights of okra plants in both seasons with exception of the combination of inoculation and nitrogen forms on fruits fresh and dry weights in the 2nd season. The best treatment was the combination between inoculated plants received 5% sawdust compost and fertilized with nitrogen in the form of nitric acid solution.

Nitrogen and phosphorus uptake by okra fruits:

Table (4) illustrated the effect of different manural treatments on nitrogen and phosphorus uptake by okra fruits for both seasons. Data reflects significant results due to the different treatments. However, inoculation with PDB was clearly effective in increasing N and P uptake by okra fruits in both seasons. This increase was presumably due to improvement of nutritional status of okra plants and synergistic effect due to growth promoting substances. In that concern, Koreish *et al.* (1998) found that soil nutrients especially phosphorus and micronutrients were significantly improved by PDB inoculation. They also found that inoculation by PDB enhanced nutrient uptake by maize plant compared to uninoculated treatments.

Concerning compost application, the results clearly showed that the total uptake of N and P were greatly enhanced, with significant differences in all cases, by the presence of decomposable organic material which caused high accumulation of the elements by plant fruits with increasing the level of added compost. This could be due to the dual beneficial effect of organic material which led to increase the available forms of these nutrients and greatly flourish plant growth. Obtained results were in agreement with those of Kropisz (1992) and Kalembasa and Deska(1998).

As in Table (4), it is obvious that nitrogen fertilization with any form was effective in increasing the uptake of N and P by okra fruits than the control treatments through the both seasons. These increases were significant in all cases. On the other hand, application of the acidic form (B) of N showed the peak of N and P uptake in all cases while the lowest was the amid form (E) which showed the least effect on the uptake of these nutrients. Thus, it could be concluded that acidification of soil through acid or nitric acid-calcium nitrate form addition was effective to increase the availabilities of these nutrients in soil which were reflected on plant uptake. Obtained results were in harmony with those of Thomson et al.(1993) and Yiqing et al.(1999).

Table (4): Nitrogen and phosphorus uptake (mg/pot) by okra fruits grown in calcareous soil as affected by sawdust compost, phosphate dissolving bacteria inoculation and nitrogen treatments.

Inoc.	Compost rate %	Nitrogen treatments A	B	C	D	E	Mean	L.S.D at 0.05 Level
				1st season, nitrogen				
Non-inoc.	0	95.00	273.36	177.64	197.80	205.29	189.82	Inco : 39.40
	2.5	194.67	409.92	332.85	335.97	292.70	313.22	Comp. : 42.53
	5	321.50	607.75	388.68	385.56	398.30	420.36	N : 44.42
	Mean	203.72	430.34	299.72	306.44	298.76	307.80	Inoc x comp. : N.S
Inoc.	0	120.99	356.43	317.33	291.45	292.97	275.83	Inoc. x N : N.S
	2.5	227.20	514.56	558.39	403.36	446.55	430.01	Comp. x N : N.S
	5	376.92	592.18	489.34	420.20	434.12	462.55	Inoc. x comp. x N : N.S
	Mean	241.70	487.72	455.02	371.67	391.21	389.46	
Mean		222.71	459.03	377.37	339.06	344.99	348.63	
				2nd season, nitrogen				
Non-inoc.	0	96.57	257.34	196.17	215.39	181.24	189.34	Inco : 24.22
	2.5	232.95	363.51	297.35	341.01	312.08	309.38	Comp. : 30.28
	5	352.46	490.37	359.89	499.09	406.17	421.60	N : 38.76
	Mean	227.33	370.41	284.47	351.83	299.83	306.77	Inoc x comp. : N.S
Inoc.	0	140.22	318.20	385.59	305.35	279.30	285.73	Inoc. x N : 54.15
	2.5	252.70	500.42	461.40	395.23	427.28	407.41	Comp. x N : N.S
	5	373.76	631.25	533.96	572.42	504.66	523.21	Inoc. x comp. x N : N.S
	Mean	255.56	483.29	460.32	424.33	403.75	405.45	
Mean		241.45	426.82	372.40	388.08	351.79	356.11	
				1st season, phosphorus				
Non-inoc.	0	32.50	94.10	58.16	72.15	65.37	64.46	Inco : 16.16
	2.5	76.14	165.76	141.75	138.69	156.97	135.86	Comp. : 21.72
	5	135.03	214.50	145.76	192.19	166.99	170.89	N : 17.98
	Mean	81.22	158.12	115.22	134.34	129.78	123.74	Inoc x comp. : N.S
Inoc.	0	41.34	113.46	95.20	127.30	114.38	98.34	Inoc. x N : N.S
	2.5	88.44	249.24	263.73	207.82	218.69	205.58	Comp. x N : 44.25
	5	149.22	271.53	233.14	213.40	221.78	217.81	Inoc. x comp. x N : N.S
	Mean	93.00	211.41	197.36	182.84	184.95	173.91	
Mean		87.11	184.77	156.29	158.59	157.37	148.82	
2nd season, phosphorus								
Non-inoc.	0	42.12	88.72	76.38	78.01	56.47	68.34	Inco : 10.59
	2.5	92.85	175.97	139.27	138.27	120.23	133.32	Comp. : 14.91
	5	137.82	248.13	172.59	207.23	146.62	182.48	N : 16.55
	Mean	90.93	170.94	129.41	141.17	107.77	128.05	Inoc x comp. : N.S
Inoc.	0	63.96	154.85	158.61	128.88	118.55	124.97	Inoc. x N : 23.67
	2.5	110.24	227.72	191.47	180.43	195.10	180.99	Comp. x N : 28.98
	5	157.16	298.51	228.25	276.66	251.06	242.33	Inoc. x comp. x N : N.S
	Mean	110.45	227.03	192.78	195.32	188.24	182.76	
Mean		100.69	198.99	161.10	168.25	148.01	155.41	

Inoc. = Inoculation

The double and triple interaction effects between the individual factors in this study on N and P uptake were generally insignificant within their combination except in two cases. Meanwhile combination of inoculation and nitrogen forms applied gave significant differences among their treatments as in case of N and P uptake in the 2nd season. Another case was the combination between compost and nitrogen treatments which showed significant response as in case of P uptake in both seasons.

Residual effect of different soil application on some chemical and biological properties of the calcareous soil:

Data presented in Table (5) showed that addition of 2.5 or 5% of sawdust compost to the studied calcareous soil led to slight decrease in soil pH. However, application of the previous rates of sawdust compost in combination with PDB inoculation was relatively more effective to lower pH values than those of the non-inoculated ones. In this respect several investigators observed a slight decrease in soil pH after organic matter addition which is probably caused by production of CO_2 and organic acids during the breakdown of the organic matter. This certainly contributes to the decrease in soil pH and nutrients availability (Khalil and El-Shinnawi, 1989). Regarding the effect of nitrogen fertilization and its form, pH values were general affected. While application of the acidic form of N showed the peak of reducing the pH values in all cases, followed by the nitric acid-calcium nitrate(1:1)mixture (C) and calcium nitrate form (D) and the amid form, urea (E), respectively. In this concern, Thomson et al.(1993) study the effect of NO_3^--N and NH_4^+-N on acidification of the bulk soil, where they found that the nutrient availability increased due to acidification of the rhizosphere.

Compost application at the two used rates increased the organic matter content and the availability of N of the tested soil, especially the rate of 5% compared with control treatments either in the presence or without PDB inoculation. On the other hand, nitrogen fertilization with any form and inoculation with PDB led to slight increase in these parameters over the control treatments and this was true in all treatments. This increase is likely to be due to the beneficial effect of root exudates and debries during plant growth as well as increasing of the microbial activities in the soil during the decomposition of the compost material. Many earlier investigators revealed that the addition of organic manure increased the carbon content and mineral N of the soil (Ismail et al.1996 and Estefanous et al.1997)and the results which obtained here is confirm these findings.

Data in Table (5) also indicate the superiority of inoculated treatments on the availability of P than none inoculated one. This effect was more pronounced in none-amended soil and this reflects the beneficid effect of PDB inoculation. This result seems to be due to the release of soluble phosphorus during the degradation of the added organic materials by soil microorganisms. The decrease in soil pH after organic matter addition and PDB inoculation may contribute to P availability (Khalil *et al.*, 1992 and Estefanous *et al.*, 1997).

Data in Table (5) showed that, bacterial plate counts, phosphate dissolving bacteria and dehydrogenase activity were generally increased by the addition of sawdust compost to the tested soil. This increase maight be due to the introduction of a large amount of living microorganisms and readily-utilizable carbon sources to the soil during organic manure application. These results agreed with previous findings of Luo and Sun (1994) and Estefanous *et al.*(1997) who found that the addition of organic

Table (5): Some chemical and biological properties of calcareous soil as affected by different treatments, after 175 days of okra planting.

Compost rate %	Non-inoculated						Inoculated					
	A	B	C	D	E	Mean	A	B	C	D	E	Mean
pH values												
0	7.9	7.8	7.8	7.8	7.9	7.8-7.9	7.9	7.5	7.72	7.80	7.82	7.5-7.9
2.5	7.6	7.4	7.4	7.5	7.5	7.4-7.6	7.5	7.3	7.32	7.36	7.38	7.37.5
5	7.5	7.3	7.4	7.4	7.4	7.3-7.5	7.4	7.2	7.30	7.30	7.35	7.27.4
Range	7.5-7.9	7.3-7.8	7.4-7.8	7.4-7.8	7.4-7.9	7.3-7.9	7.4 -7.9	7.2-7.5	7.3-7.7	7.3-7.8	7.4-7.8	7.2-7.9
Organic-matter (%)												
0	0.83	0.86	0.85	0.89	1.13	0.91	0.90	0.96	0.98	0.93	0.94	0.94
2.5	1.72	1.74	1.76	1.80	1.85	1.77	1.54	1.82	1.80	1.88	1.94	1.80
5	2.19	2.34	2.35	2.38	2.35	2.32	2.08	2.76	2.44	2.26	2.55	2.42
Mean	1.58	1.65	1.65	1.69	1.78	1.67	1.51	1.85	1.74	1.69	1.81	1.72
Mineral- N (ppm NH_4^+- N and NO_3^- -N)												
0	54	88	74	82	74	74.4	59	95	82	76	84	79.2
2.5	66	98	92	102	96	90.8	63	112	88	90	102	91.0
5	74	106	100	114	109	100.9	68	106	110	116	124	104.8
Mean	64.7	97.3	88.7	99.3	93.0	88.7	63.3	104.3	93.3	94.0	103.3	91. 7
Available –P (ppm)												
0	9.8	10.4	11.2	11.1	11.2	10.74	12.4	13.4	13.1	14.8	13.7	13.48
2.5	12.8	12.6	11.8	12.4	12.7	12.46	14.4	15.0	15.2	15.8	16.8	15.44
5	12.6	13.2	14.6	13.6	12.8	13.36	14.3	17.8	16.5	17.1	18.0	16.74
Mean	11.7	12.1	12.5	12.4	12.2	12.2	13.7	15.4	14.9	15.9	16.2	15. 2
Viable microbial counts, ($X10^6$ cell/g dry soil)												
0	6.7	7.0	8.4	8.0	8.8	7.78	7.2	8.6	10.4	9.6	11.2	9.40
2.5	61.0	54.0	73.0	59.0	83.0	66.0	52.0	65.0	66.0	89.0	70.0	68.40
5	50.0	77.0	68.0	89.0	71.0	71.0	61.0	81.0	73.0	88.0	96.0	79.80
Mean	39.2	46.0	49.8	52.0	54.3	48.3	40.1	51.5	49.8	62.2	59.1	52.5
Phosphate dissolving bacteria, ($X10^4$ cell/g dry soil)												
0	3.8	5.6	4.8	7.4	3.8	5.08	42.0	38.0	50.0	46.0	48.0	44.80
2.5	66.0	96.0	72.0	86.0	68.0	77.60	120.0	160.0	168.0	148.0	132.0	145.60
5	82.0	125.0	108.0	112.0	98.0	105.0	140.0	156.0	176.0	144.0	172.0	157.60
Mean	50.6	75.5	61.6	68.5	56.6	62.6	100.7	118.0	131.3	112.7	117.3	116.0
Dehydrogenase activity,(µl H/g dry soil/24 hrs at 30 °C)												
0	11	36	26	20	73	33.20	42	106	110	95	135	97.6
2.5	156	186	218	192	215	193.40	206	288	290	317	256	271.4
5	175	293	240	233	224	233.00	266	367	320	328	319	320.0
Mean	114.0	171. 7	161. 3	148.3	170.7	153.2	171.3	253.7	240.0	246.7	236.7	229.7

manures to the soil increased its microbial population and its microbial activity. On the other hand, the counts of microbial groups and dehydrogenase activity were increased by the inoculation of okra plants with PDB and fertilization with any form of nitrogen and these parameter were almost similar when the soil was treated by different nitrogen forms. This result may be due the higher count of phosphate dissolving bacteria in this treatment and the beneficial effect of mineral nitrogen fertilization on the multiplication and activity of microorganisms.

From the above mentioned results, it could be concluded that adding sawdust compost to a calcareous soil in presence of acidic nitrogen fertilizer form as well as phosphate-bacteria inoculation could be recommended to obtain the best results for okra fruits yield and favourable nutrients uptake, as well as good soil fertility.

REFFRENCES

Abd El-Lateef, E.M.; M.M Selim and T.G. Behairy (1998). Response of some oil crops to biofertilization with phosphate dissolving bacteria associated with different levels of phosphatic fertilization. Bulletin of the National Res. Center, Cairo, 23(2):193-202.

Abdel-Hafez, A.M. (1966). Some studies on acid producing microorganisms in soil and rhizospere with special reference to phosphate dissolvers. Ph. D. Thesis, Fac. Agric., Ain Shams Univ., Egypt.

Allen, O.N. (1953). Experiments in soil bacteriology, Burgess pub. Co. U.S.A.

Black, C.C.; D.D.Evans; F.E. Ensminger;J.L. White;F.E. Clark and R.C. Dinauer(1965). Methods of Soil Analysis. II. Chemical and microbiological properties. Amer. Soc. Agron. Inc.Madison, Wisconsin, U.S.A.

Casida, L.E.; D.A. Klein and T. Santoro (1964). Soil dehydrogenase activity. Soil Sci., 98:371-378.

Chapman, H.D. and P.F.Pratt (1961).Methods of Analysis for Soils, Plants and Waters". Univ.Calif., USA.

Estefanous, A.N.; F.T. Mikhaeel and G.G. Antoun (1997). Effect of mycorrhizal inoculation and organic fertilization on microbial activity and nutrient release in soil. Bull. Fac. Agric. Cairo, 48:187-200.

Fenn, L. B. and S. Feagley (1999): Review of beneficial uses of calcium and ammonium salts for stimulating plant growth and metabolite translocation. Communication in Soil Sci & Plant Analysis 30 (19/20): 2627-2641. (c.f. Hot. Abst. 70(6):4885, 2000).

Ismail, A. S.; A.S. El-Sebaay; S.A. Saleh and A.F. Abdel-Wahab (1996). Effect of application of mineral and organic amendments on nodulation, cowpea growth and certain chemical properties of calcareous soils. 6th Conf.Agric. Dev. Res., Ain Shams Univ., Cairo, Dec. 17-19,1996.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Private Limited, New Delhi.

Kalembasa, S. and J. Deska (1998). The possibility of utilizing vermicompostss in the cultivation of lettuce and tomato. In Ekologiczne aspekty produkcji orgrod-niczej, Poznzn, Poland(c.f.Hort. Abst., 69(9): 788,1999).

Khalil, R.A. and M.M. El-Shinnawi(1989). Humification of organic matter in soil affecting availability of phosphorus from its mineral compounds. Arid Soil Res., 3:77-84.

Khalil, S.; T.E. Loynachan and H.S. Mc. Nabb(1992). Colonization of soybean by mycorrhizal fungi and spore populations in Iowa soils. Agron. J., 84:832-836.

Koreish, E.A.; M.E. El-Fayoumy and H.M. Ramadan (1998). Contribution of vesicular arbusclar mycorrhizal and phosphorin in acquisition of phosphorus and micronutrients by maize(*Zea mays*,L.) in a calcareous soil. Egypt J. Soil Sci., 38(1-4):101-121.

Kropisz, A. (1992). Influence of fertilization with compost on yield of vegetables and their content of mineral elements. Annals of Warsaw Agric. Univ., (16): 9-13. (c.f. Soils and Fert., 57(1): 1017, 1994).

Luo, A.C. and X. Sun (1994): Effect of organic manure on the biological activities associated with insoluble phosphorus release in a blue purple paddy soil. Communication in Soil Science and Plant Analysis, 25:2513-22.

Marsh, J.D.M. and A.J. Rixon (1991). Effect of heavy additions of organic residues on physical characteristics of three soil types in Queensland, Australis. Soil and Tillage Research, 20(1): 109-122. (c.f. Soils and Fert., 54(9):11218, 1991).

Mohamed, E.I. and A.A. Gamie (1999). Evaluation of some organic fertilizers as substitutions of chemical fertilizers in fertilizing onion. Egypt J. Appl. Sci., 14(7): 664-678.

Montagu, K.D. and K.M. Goh (1990). Effect of forms and rates of organic and inorganic nitrogen fertilizers on yield and some quality indices of tomatoes (*Lycopersicon escultentum* Miller). New Zealand J. Crop & Hort. Sci., 18(1): 31-37. (c.f. Soils and Fert., 54(8): 10739, 1991).

Page, A.L.; R.H. Miller and D.R. Keeny (1982). Methods of Soil Analysis. II. Chemical and microbiological properties." Soil Sci., 9 Amer., Madison, Wisconsin, USA.

Ritzinger, C.H.S.P.; R. Mcsorley and R.N. Gallaher (1998). Effect of *Meloidogyne arenaria* and mulch type on okra in microplot experiments. J. Nematology, 30(4): 616-623.

Saad, O.A.D. and A.M.M. Hammad (1998). Fertilizing wheat plants with rock phosphate combined with phosphate dissolving bacteria and VA-mycorrhizae as alternative for Ca-superphophate. Annals of Agric. Sci. cairo, 43(2):445-460.

Selvi, D. and R. Perumal (1997). Microfood with and without organics and biofertilizers on growth and development of bhendi. Madras Agric. J., 84(10):625-626.

Snedecor, G.W. and W. Cochran (1980). Statistical Methods" 7th Ed., Iowa State Univ. Press., Amer., Iowa, U.S.A.

Thomson, C.J.; H. Marschner and V. Romheld (1993). Effect of nitrogen fertilizer form on pH of the bulk soil and rhizosphere and on the growth, phosphorus and micronutrients uptake of bean (c.f.J.Plant Nutr., 16(3):493-506).

Wen, T.X.; H. Ikeda and M. Oda (2000). The absorption, translocation and assimilation of urea, nitrate or ammonium in tomato plants at different plant growth stages in hydroponic culture. Scienta Horticulturae, 84(3/4):275-283, (c.f. Hort.Abst. 70(7):6033).

Yiqing, H.; S. Terabayashi; T. Asaka and T. Namiki (1999). Effect of restricted supply of nitrate on fruit growth and nutrient concentrations in the petiol sap of tomato cultured hydroponically. J. Plant Nutr., 22(4/5): 799-811, (c.f. Hort. Abst., 69(8):6963).

تأثير التلقيح ببكتيريا الفوسفات والسماد العضوي من نشارة الخشب والتسميد النيتروجيني بمصادر مختلفة على إنتاجية البامية وبعض خصائص التربة الجيرية

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تم إجراء تجربتي أصص خلال موسمي ١٩٩٩ , ٢٠٠٠ في مركز البحوث الزراعية بالجيزة باستخدام تربة جيرية وذلك لدراسة تأثير التلقيح بالبكتريا المذيبة للفوسفات و السماد العضوي الناتج من نشارة الخشب و التسميد النيتروجيني بمصادر مختلفة على نمو و إنتاج نباتات البامية وكذلك دراسة بعض التغيرات في الخصائص الكيميائية و البيولوجية للتربة الجيرية بعد زراعة البامية. و قد استخدمت سلالة باسلس ميجاتيريم المذيبة للفوسفات و استخدم معدلين من التسميد العضوي هما ٢,٥% و ٥% بالإضافة الى معاملة الكنترول (بدون تسميد عضوي). و

التسميد النيتروجيني استخدم :(ب) محلول حامض نيتريك ١,٠ اساسى، (ج) مخلوط من حامض النيتريك و نترات الكالسيوم (١:١) ، (د) محلول نترات الكالسيوم و (ه) محلول اليوريا على أساس المحتوي النيتروجيني مقارنة بمعاملة بدون إضافة نيتروجين معدني (ا).

أوضحت النتائج المتحصل عليها أن تلقيح البامية بالبكتريا المذيبة للفوسفات مع إضافة السماد العضوي من نشارة الخشب أدى الى زيادة معنوية في نمو النبات و إنتاج قرون البامية وكذلك امتصاص العناصر. وكان أعلى زيادة في هذه القياسات عند استخدام معدل تسميد عضوي ٥% وقد أوضحت النتائج المتحصل عليها أيضا أن التسميد النيتروجيني مهم جدا لنباتات البامية في مثل هذه التربة بغض النظر عن صورة النيتروجين المضاف. ومن ناحية أخرى فان صور النيتروجين الحامضية و النصف متعادل أعطى نتيجة ايجابية في تيسر العناصر مثل الفوسفور و البوتاسيوم و الذي انعكس غلى امتصاص هذه العناصر بواسطة قرون البامية. وأدى التسميد العضوى و التلقيح بالبكتريا المذيبة للفوسفات الى زيادة العدد الكلي للميكروبات و أعداد البكتريا المذيبة للفوسفات و نشاط إنزيم الديهيدروجينيز و كذلك زيادة في تيسر عناصر ن، فو، بو في التربة. عموما فان إضافة الأسمدة العضوية أدى الى زيادة النسبة المئوية للمادة العضوية في التربة و انخفاض طفيف في رقم الpH لذلك فان إضافة السماد العضوي من نشارة الخشب الى الأرض الجيرية في وجود التسميد النيتروجيني بالصورة الحامضية و كذلك التلقيح بالبكتريا المذيبة للفوسفات قد يوصي به للحصول على أعلى محصول من البامية و امتصاص اكبر للعناصر .